CULTURES OF UREDINEAE IN 1909[1]

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The year 1909 marks the beginning of the second decade of culture work by the writer. The present report is preceded by nine other similar reports[2] covering work done between 1899 and 1908 inclusive, each issued annually except the second one, which covered two years. The following account of the work for the year 1909 is divided into a general introductory part, a list of negative results, in which the sowing of the spores did not bring hoped-for infection but the record seemed worth preserving for use in directing future work, and a list of positive results, in which the sowing of spores caused an infection that gave rise to characteristic fruiting bodies. The successful sowings largely belonged to species previously cultivated, and are recorded to verify or amplify existing knowledge. A small number of successful sowings were made with species never before cultivated, and whose alternate forms had never before been associated.

The work of the year was carried on under adverse and trying conditions. A new building for the experiment station was begun in the previous autumn, and was located upon the ground where for many years a great variety of plants has been grown, especially brought together for this work. It was in effect a small botanical garden filled with plants from all over the continent known to serve as hosts for different species of rusts, and from which plants were in large part drawn for the cultures. As many plants as possible were removed to another plot of ground some distance away, but many species were wholly lost. The seedlings of self-sown annuals were especially missed in providing potted plants for the spring's work. The heavy infectional work had only begun in April when it became necessary to abandon the greenhouses where the work was in progress, so they

[1] Read before the Botanical Society of America at the Boston meeting, December 29, 1909.

[2] See Bot. Gaz. 29: 268–276, 35: 10–23; Jour. Myc. 8: 51–56, 10: 8–21, 11: 50–67, 12: 11–27, 13: 189–205, 14: 7–26; and Mycol. 1: 225–256.

could be wrecked. The temporary quarters provided in another greenhouse were scarcely in working order before another move was necessary. This time a hastily constructed glass lean-to, placed on the east sidé of a frame building, was made from the wreckage of the two demolished houses. Good conditions for securing infection could not be uniformly maintained. Not only was the practical part of the work hampered in this manner, but the time required in designing the botanical rooms and furnishings for the new experiment station, making temporary adjustments in the old quarters, and finally moving into the new building, seriously interfered with the correspondence and the excursions by which material and information are brought together for making cultures of untried species.

The chief excursion of the year was made by Mr. F. D. Kern and the writer to South Carolina, with incidental stops in Tennessee and North Carolina. It occupied a week during the middle of March. The first stop was at Knoxville, Tenn., where Prof. S. M. Bain, of the University of Tennessee, courteously aided us in every way possible. Upon our return journey we spent a day at Asheville, N. C. At both places culture material was secured. The trip was especially planned, however, to visit the localities made famous to mycologists by the very important contributions of H. W. Ravenel.

Mr. Ravenel belonged to a distinguished southern family, whose estate lay some miles north of Charleston on the Santee Canal, a water way long since fallen into disuse. It was here that he obtained the material for the five centuries of his Fungi Caroliniani Exsiccati, issued during the decade preceding the Civil War. Nearly two days were spent most profitably in this locality. Our work was much facilitated by the intelligent interest of Mr. Octavus Cohen of Monks Corners, the nearest railway town, although not himself a botanist. We were desirous, among other things, to rediscover and identify the uncertain rust from the trunks of cedar trees, issued as no. 87 in the fifth century of the Fungi Caroliniani, under the name *Gymnosporangium Juniperi.* We were not only able to do this, deciding that it belongs to the multiform species, *G. nidus-avis,* and not to the one whose name it bears, but in addition we found two hith-

erto undetected species of the same genus, also inhabiting the red cedar, as well as other culture material. The locality is an interesting one, and deserving of further uredinological exploration.

We spent two days at Aiken, in the highlands of South Carolina, where Mr. Ravenel lived after the Civil War had swept away the family wealth. It was here that the work on his Fungi Americani Exsiccati was done. We wished especially to obtain further knowledge of *Roestelia hyalina,* a highly characteristic rust on *Crataegus* which is only known from Ravenel's original collection made at Aiken and distributed in 1878 as no. 37 in his Fungi Americani. We hoped to find a telial form from which the *Roestelia* could be grown, as we had done last year in the similar case of an isolated *Roestelia* from central Kentucky.[3] Unfortunately we failed to obtain any trace of the sought for rust, although we secured other culture material.

During the week following my associate, Mr. Kern, joined a company from the Missouri Botanical Garden at St. Louis, in a day's collecting along the bluffs of the Mississippi River south of St. Louis, securing culture material chiefly of grass and sedge rusts.

Another brief but important trip was made by Mr. Kern the first week in June to Leland in the northern part of the southern peninsula of Michigan, about 300 miles north of Lafayette, Ind. This was in consequence of observations made by Mr. Kern and the writer in that locality during the previous September. Horn-like aecia on *Sorbus, Aronia* and *Amelanchier* are quite common in the northern United States and Canada, and often occur in herbaria, usually under the name *Roestelia cornuta.* Morphological studies made by Mr. Kern convinced him some time ago that the similar aecia on the three host genera belong to three independent species of rusts, and since then we have been trying to secure suitable material for cultures. Last year we were able to show that telia of *Gymnosporangium cornutum* on the branches of *Juniperus Sibirica* produced the aecia on *Sorbus,* and that telia of *G. Davisii* on the leaves of the same host produced the aecia on *Aronia.*[4] In searching in northern Michigan for clues

[3] Mycol. 1: 226. 1909.

[4] Mycol. 1: 240–242. 1909.

to the *Amelanchier* form we most fortunately found a very small weather-beaten plant of *Amelanchier* not over six or eight inches high, bearing at the time about a score of leaves, and every leaf thickly covered with the characteristic horn-like aecia. No other plants of *Amelanchier* infected with the same sort of aecia could be found in the region, although they often bore aecia of other species. The plant in question did not occur near *Juniperus Sibirica,* although that juniper was very common, but much to our surprise was associated with *Juniperus horizontalis,* a trailing form of the red cedar, that produces circular mats up to fifty feet in diameter and rises only three to five inches from the ground. No other form of red cedar occurs in the region, and even this one is not abundant. In the midst of one of these red cedar mats, some six feet in diameter, we found on September 7 the heavily infected *Amelanchier* just mentioned. It was too late in the season to hope to find telia. We did, however, detect some remains of what appeared to be telial galls on the larger branches close to the infected *Amelanchier,* from which the aecia might have been derived. It was to ascertain if telia subsequently developed on this particular red cedar, and, if so, to secure some for cultures, that Mr. Kern again visited Leland. The highly satisfactory results of the trip are given later in this paper under the report of cultures of species never before recorded.

In this connection an error in the report of cultures for 1908 should be pointed out. The record of *Gymnosporangium Davisii* Kern,[5] should have been listed among "Successful cultures reported for the first time." Studies have since shown that the form grown by Dr. Ed. Fischer of Bern, Switzerland, and which he subsequently named *G. Amelanchieris* is quite distinct from *G. Davisii.* The aecial host of the European form is a true *Amelanchier* (service-berry), and not an *Aronia* (choke-berry). The assumption that it was an *Aronia,* a genus not represented in the Swiss flora, came from confusion in interpreting the synonymy. The very similar aecia on *Amelanchier* in America produce a gall on the stems of the red cedar ,as the present season's work has demonstrated, while the aecia on *Amelanchier* in Europe produce small sori on the leaves of the common juniper. The

[5] Mycol. 1: 241–242. 1909.

whole paragraph beginning with the third line on page 242 of the last season's report is largely irrelevant, and should be stricken out.

Most of the experimental part of the culture work of each year is done in the spring, and while in progress it wholly absorbs the time of one person in addition to that of the regular workers in the department. This year Miss Louise M. Falk, of Davenport, Iowa, a senior honor student in the University of Iowa, was recommended for the position by Professor Thomas H. Macbride. Miss Falk was in charge of the work from April 1 to June 3. She showed great enthusiasm and assiduity in conducting the cultures, although the turmoil of building and moving put the possibility of entirely satisfactory manipulation out of the question, as well as introduced most annoying interference. As for the year or two past, most of the cedar rust cultures were made by Mr. Kern. The investigations as a whole are a part of the work conducted by the botanical department of the Indiana Experiment Station, and are financed from the Adams fund appropriated by the general government for scientific research.

Those who assisted this year by supplying culture material and communicating field observations are most gratefully mentioned. Mr. E. Bethel, Denver, Colo., heads the list with forty-six collections of culture material. Messrs. J. F. Brenckle, Kulm, N. D., J. M. Bates, Red Cloud, Neb., and W. P. Fraser, Pictou, Nova Scotia, each sent between twenty and thirty collections, while a much smaller number was sent by Messrs. O. E. White, Brookings, S. D., A. O. Garrett, Salt Lake City, Utah, C. F. Baker, Claremont, Calif., J. J. Davis, Racine, Wis., E. Bartholomew, Stockton, Kans., E. W. Olive, Brookings, S. D., John L. Sheldon, Morgantown, W. Va., F. D. Heald, Austin, Texas, H. W. Barre, Clemson College, S. C., W. P. Kelley, Honolulu, Hawaii, F. E. Lloyd, Zacatecas, Mex., Aven Nelson, Laramie, Wyo., F. L. Stevens, West Raleigh, N. C., and Guy W. Wilson, Fayette, Iowa. Plants for particular culture work were sent by Dr. William Trelease, of the Missouri Botanical Garden, St. Louis, Mo. Thanks are extended to the above individuals, and to others who aided in the year's investigations.

During the present season 178 collections of material with resting spores and 18 collections with active spores were employed, from which 684 drop cultures were made to test the germinating condition of the spores. Out of the 178 collections with resting spores 95 could not be brought to germination, leaving 83 collections of available material to serve for the projected cultures. These 83 collections with resting spores and 18 with active spores belonged to about 70 species of rusts. Altogether 345 sowings were made, employing for the purpose 97 species of hosts, these being grown in pots.

The results of this work are given in the following paragraphs, and are divided into negative results, positive results with species whose life cycles have already been ascertained by the writer or other investigators, and positive results with species whose life cycles are now first completed and placed on record.

NEGATIVE RESULTS:—Quite a number of collections gave good germination of the spores, and these were sown on plants in the hope of discovering the alternate host, but no infections were secured. The following may be recorded to serve for reference in future studies, although not so much importance can be attached to these results as in former years, owing to unsatisfactory conditions, as stated above:

1. PUCCINIA on *Carex tenella* Schk., collected at Pictou, Nova Scotia, by Prof. W. P. Fraser, was sown on *Boehmeria cylindrica, Apocynum cannabinum, Lepargyraea canadensis, Symphoricarpos pauciflorus, Rudbeckia laciniata* and *Iva frutescens,* with no infection.

2. PUCCINIA on *Carex tenuis* Rudge, collected at Pictou, Nova Scotia, by Prof. W. P. Fraser, was sown on *Aster paniculatus, Solidago canadensis, Erigeron annuus, Onagra biennis* and *Ambrosia trifida,* with no infection.

3. PUCCINIA on *Carex Bonplandii minor* Vasey, collected at Granby, Colo., by Mr. E. Bethel, was sown on *Aster Tweedii, A. paniculatus, A. multiflorus* and *A. Drummondii,* with no infection. The determination of the host was made by Mr. Theo. Holm.

4. PUCCINIA on *Carex Backii* Boott, collected in Colorado, by

Mr. E. Bethel, was sown on *Lactuca sativa, Artemisia dracunculoides, Ambrosia trifida, Grindelia squarrosa* and *Laciniaria spicata,* with no infection. The determination of the host was made by Mr. Theo. Holm.

5. PUCCINIA on *Carex siccata* Dewey, collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown on *Ambrosia trifida* and *Carduus undulatus,* with no infection.

6. PUCCINIA RUBIGO-VERA Auct., on *Hordeum jubatum,* collected at Brookings, S. D., by Mr. O. E. White, was sown on *Lycopsis arvensis* (on 3 different dates), *Heliotropium curassavicum* (on 3 dates), *Myosotis palustris* (3 dates), *Lithospermum canescens, L. arvense, L. angustifolium, Hydrophyllum virginicum, Ceanothus americanus, Callirrhoe involucrata, Symphoricarpos racemosus, Petalostemon purpurpeum, Laciniaria punctata* and *Ambrosia trifida,* with no infection.

7. PUCCINIA DISTICHLIDIS E. & E., on *Spartina gracilis* Trin., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown on *Lepargyraea canadensis, Mimulus ringens, Symphoricarpos recemosus, Polygala Senega, Grindelia squarrosa* and *Carduus undulatus,* with no infection.

8. PUCCINIA SUBSTERILIS E. & E., on *Stipa viridula* Trin., collected at Eldorado Springs, Colo., by Mr. E. Bethel, was sown on *Tithymalis arkansanus coloradensis, Arabis Holboellii, Grindelia squarrosa* and *Eupatorium serotinum,* while another collection with same data was sown on *Viola sororia, Mimulus ringens, Myosotis palustris, Aster ericoides* and *A. multiflorus,* all with no infection.

9. PUCCINIA STRIATULA Peck, on *Calamagrostis canadensis* (Michx.) Beauv., collected at Wind Lake, Wis., by Dr. J. J. Davis, was sown on *Thalictrum alpinum, T. dioicum, T. purpurascens, Actaea alba, Phacelia bipinnatifida, Hydrophyllum virginicum* and *Polygonatum biflorum,* with no infection.

10. PUCCINIA VIRGATA Ellis & Ev., on *Chrysopogon avenaceus* (Michx.) Benth., collected at Asheville, N. C., by Mr. F. D. Kern, was sown on *Dirca palustris, Viola sororia, Hydrophyllum virginicum, Mimulus ringens, Chelone glabra, Symphoricarpos pauciflorus* and *Ambrosia trifida,* with no infection. Similar

material from Nebraska was sown two years ago on four other species of hosts.[6]

11. PUCCINIA ELLISIANA Thüm., on *Andropogon scoparius* Michx., collected at Ayr, Neb., by Rev. J. M. Bates, was sown on *Ceanothus americanus, Aesculus glabra, Lepargyraea canadensis, Symphoricarpos racemosus, Mimulus ringens, Laciniaria punctata, Lithospermum angustifolium, Chelone glabra, Ranunculus septentrionalis* and *Mertensia virginica.*

Another collection on the same host and by the same collector from Scotia, Neb., was sown on the first six hosts mentioned, and also on *Laciniaria spicata, L. scariosa, Cassia Chamaecrista, Hydrophyllum virginicum, Polygala Senega, Petalostemon purpureum* and *Phacelia bipinnatifida.*

The same species of rust on *A. glomeratus* (Walt.) B.S.P., collected at Asheville, N. C., by Mr. F. D. Kern, was sown on *Cassia Chamaecrista, Lepargyraea canadensis* and *Petalostemon purpureum,* as in the preceding cases, and also on *Baptisia tinctoria, Abronia fragans* and *Viola cucullata.*

The results were uniformly negative, there being no infection. In the two preceding years this rust was sown on nineteen other species of hosts.[7]

12. UROMYCES GRAMINICOLA Burr., on *Panicum virgatum* L., collected at St. Paul, Neb., by Rev. J. M. Bates, was sown on *Callirrhoe involucrata, Althaea rosea, Hibiscus militaris, Sidalcea oregana* and *Viola cucullata,* with no infection. Similar material was sown last year on four of these same hosts, and on four other species without effect.[8]

13. UROMYCES JUNCI (Desm.) Tul., on *Juncus Balticus* Willd., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown on *Pulicaria dysenterica,* with no infection. Another collection on the same host from Colorado, sent by Mr. E. Bethel, was sown on *Pulicaria dysenterica,* both seedlings and strong shoots, and on *Grindelia squarrosa* and *Arnica* sp., with no infection. In 1907 a similar collection from Nebraska was sown on fifteen other species of hosts.[9] This common American rust is usually

[6] See Jour. Myc. 14: 10. 1908.
[7] Jour. Myc. 14: 10. 1908; Mycol. 1: 231. 1909.
[8] Mycol. 1: 232. 1909.
[9] See Jour. Myc. 14: 12. 1908.

considered to be the same as the one in Europe from which it takes its name. The experiments of Fuckel, Plowright, and E. Fischer have shown that the European form produces aecia on *Pulicaria dysenterica,* and the failure of the American form to do so may mean that the two are distinct species, or that there are physiological races on different hosts. Further studies are necessary to decide the question.

14. UROMYCES ACUMINATUS Arth., on *Spartina cynosuroides* Willd., collected at Fayette, Iowa, by Prof. Guy West Wilson, was sown on *Steironema ciliatum, S. lanceolatum* and *Polemonium reptans,* with no infection. Similar material from northern Indiana has been sown in previous years on six other hosts, and also four times on *Steironema ciliatum* and two times on *S. lanceolatum,* without infection.[10]

Some years ago in a morphological study of all collections of *Uromyces* on *Spartina* then available the writer decided[11] that the form from the salt marshes of the Atlantic coast, known under the name *U. Spartinae* Farl., having somewhat larger teliospores and urediniospores, the former with more rounded apices, and the latter with thicker walls, than the western form mentioned above, occurred also in the interior of the continent, and could not be clearly separated from *U. acuminatus.* Recently my associate, Mr. F. D. Kern, has restudied the two forms, with all the data that have accumulated in the decade since my own study was completed, and is able to supplement the morphological differences which I pointed out with others, and concludes that the two forms represent distinct species. He gives the distribution of *U. acuminatus* as the wet, alluvial prairies of Iowa, Minnesota, and adjoining states, extending eastward to northern Indiana, while *U. Spartinae* is found in saline soils from Alberta southwestward to Wisconsin and Kansas, and along the Atlantic coast from Nova Scotia to Florida. Reexamining the successful cultures with *Uromyces* on *Spartina,* made in 1905 and 1907, the material for which was sent from western Nebraska,[12] it is found that the culture material agrees with *U. Spartinae* Farl. Putting all the data together, the writer's suspicions, recorded

[10] See Jour. Myc. 10: 9. 1904; 13: 193. 1907.

[11] Bot. Gaz. 34: 3. 1902.

[12] Jour. Myc. 12: 24. 1906; and 14: 17. 1908.

both in the discussion of his morphological studies and his cultural reports, cited above, that there are two species of *Uromyces* on *Spartina,* are confirmed. The aecial form of *U. Spartinae* Farl. occurs on *Steironema ciliatum* and *S. lanceolatum,* and the aecial form of *U. acuminatus* Arth. is yet unknown, although field observations made by Mr. Guy West Wilson indicate that it may occur on *Polemonium reptans.*

15. GYMNOSPORANGIUM sp., on *Juniperus virginiana* L. collected at the Santee Canal, near Monks Corners, S. C., by Mr. F. D. Kern, was sown March 24 on the leaves of *Crataegus punctata, Amelanchier erecta,* and *Cydonia vulgaris,* with no infection. On April 1 it was sown again on the same three species and on *Malus coronaria,* with no infection. It was sown again April 14 on *Crataegus* sp., and *Malus Malus,* still with no infection. On April 26 a sowing was made on *Crataegus coccinea* and *Pyrus communis* (Kiefer's Hybrid), and on May 14 a further sowing on *Crataegus cerronis, Aronia arbutifolia, Sorbus americana* and *Porteranthus stipulatus,* wholly without infection.

The failure to secure infection, although sowings were made on all the genera known to harbor aecia of the *Gymnosporangia* in the eastern United States, was probably due to the maturity of the leaves, or to some accident. It is certain on morphological grounds that this cedar rust is not a form at present recognized under established names. The rust produces large brown sori, often in series, extending along the bark of the larger branches. It has somewhat the general appearance of *Gym. nidus-avis,* causes a similar swelling of the branches, but differs in having prominently projecting sori, even before gelatinization, which are much roughened on the surface.

SUCCESSFUL CULTURES SUPPLEMENTING PREVIOUS WORK: The following species of rust were successfully grown and the facts supplement those obtained from previous cultures in this series or those recorded by other American or European investigators. In a number of cases the data here presented materially extend the previously available knowledge regarding the several species.

1. PUCCINIA PECKII (DeT.) Kellerm., on *Carex lanuginosa* Michx., collected at Red Cloud, Neb., by Rev. J. M. Bates, was

sown May 19 on *Sambucus canadensis* and *Onagra biennis,* giving no infection on the former, but giving very abundant pycnia on the latter May 28, followed by aecia June 6.

Four collections on the same host, made by Dr. J. F. Brenckle, at Kulm, N. D., were used for three successful sowings on *Onagra biennis,* giving rise to pycnia in seven to twelve days, followed by aecia in five to seven days more. Sowings on *Gaura biennis* and *Carduus undulatus* gave no infection.

A collection on *Carex trichocarpa* Muhl., made by Mr. F. D. Kern at White House, St. Louis Co., Mo., after having been sown on *Sambucus canadensis* with no infection, was sown April 21 on *Gaura biennis,* giving rise to pycnia April 30, and aecia May 10.[13]

2. PUCCINIA CARICIS (Schum.) Schröt., on *Carex aristata* R. Br., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown April 6 on *Urtica gracilis,* giving rise to pycnia April 13 and aecia April 17, both in great abundance. A similar sowing April 21 on *Boehmeria cylindrica* gave no infection. Another sowing May 4 on both hosts gave no infection on *Boehmeria cylindrica,* but produced the richest possible infection on *Urtica gracilis,* showing pycnia May 9, and aecia May 15. Beside adding another species of *Carex* to the list of hosts supplying culture material for this rust,[14] the results indicate that *Boehmeria* is not an aecial host.

It may be well to point out in this connection that the usual citation of Rebentisch for this species of rust is erroneous. This author in his Florae Neomarchicae, 1804, page 356, describes *Puccinia Caricis* as a new species in the following words: "*Sparsa minutissima punctiformis, capsulis cylindraceis apice utrinque attenuatis. In foliis Caricis praecocis Jacq.*" Only the one host species is named, neither the description nor the host tally with those known to belong to the rust having its aecia on *Urtica,* as may be seen by consulting Sydow's Monographia Uredinearum. They, however, do agree well with those given by Sydow under *Puccinia silvatica,* to which species Rebentisch's name should doubtless be referred.

[13] For previous cultures see Bot. Gaz. **35**: 13. 1903; Jour. Myc. **8**: 55. 1902; **11**: 58. 1905; **12**: 15. 1906; **13**: 195. 1907; and Mycol. **1**: 233. 1909.

[14] For previous cultures see Bot. Gaz. **29**: 270. 1900; **35**: 16. 1903; Jour. Myc. **8**: 52. 1902; **12**: 15. 1906; and **14**: 14. 1908.

3. PUCCINIA UNIVERSALIS Arth., on *Carex stenophylla* Wahl., collected at Eldorado Springs, Colo., by Mr. E. Bethel, was sown April 26 on *Arabis Holboelli, Sambucus canadensis, Urtica gracilis* and *Artemisia dracunculoides.* All remained free from infection except the last, on which pycnia appeared May 5, and aecia May 14. This is a confirmation of the result obtained in 1907.[15] In making the cultures and writing up the results of that year it was overlooked that the combination which was then established had been repeatedly suggested by Rev. J. M. Bates. In the spring of 1906 Rev. Bates sent a collection of rust on *Carex stenophylla,* obtained at Boelus, Neb., on June 25, 1906, and on the packet he wrote that it was associated with aecia on *Artemisia longifolia.* This came too late in the season to be tested by a culture. In a letter received in September of the same year he stated that his field observations made it almost certain that this *Carex* rust and the *Artemisia* aecia were alternate forms of one species. Both my associate, Mr. Kern, and myself were at that time of the opinion that the aecia on *Artemisia* belonged to the telia on the same host, and so firmly did we believe this error that when material for cultures was at hand the following spring, we had forgotten Rev. Bates' suggestion, and we also overlooked the memorandum in our book of suggestions for future work.

4. PUCCINIA CARICIS-ASTERIS Arth., on *Carex festiva* Dewey, the host being determined by Mr. Theo. Holm, collected August 15, 1908, at Granby, Colo., by Mr. E. Bethel, was sown May 17 in accordance with the suggestion of the collector on *Aster adscendens* Lindl. (*A. Tweedyi* Rydb.), giving rise to pycnia which were first noticed May 31, although they may have appeared earlier, and to a few aecia June 6. A sowing was also made at the same time on *Agoseris glauca* with no infection.

Another collection made in the same vicinity five days later was sown May 22 on *Aster adscendens* and produced abundant pycnia May 29, and many aecia June 4. These cultures bring forward a new set of hosts, and show the species to be of wide distribution in America.[16]

[15] See Jour. Myc. 14: 21. 1908.

[16] For previous cultures see Bot. Gaz. 35: 15. 1903; Jour. Myc. 8: 54. 1902; and 14: 13. 1908.

5. PUCCINIA SUBNITENS Diet., on *Distichlis spicata* (L.) Greene, collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown April 23 on *Corydalis aurea* Willd., with no infection, and also on *Atriplex hastata,* giving pycnia May 3, and aecia May 12. Another sowing was made April 24 on *Corydalis sempervirens* (L.) Pers. (*C. glauca* Pursh), with no infection, and also on *Atriplex hastata* and *Chenopodium album,* both of which gave infection, showing pycnia April 31, and aecia later.[17] The chief object in again growing this rust was to see if it would infect species of *Corydalis* on which occur *Aecidium fumariacearum* Kellerm. & Sw. (*A. Corydalis* Webber), the aecia and aeciospores of which resemble those belonging to *Puccinia subnitens.* The results, however, are inconclusive, and further cultures must be attempted before the question can be settled.

6. PUCCINIA AMPHIGENA Diet., on *Calamovilfa longifolia* (Hook.) Hack., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown May 22 on *Smilax hispida,* and gave numerous pycnia May 31, and aecia June 4. This extends the geographical range from which material has been received for successful cultures.[18]

7. PUCCINIA FRAXINATA (Schw.) Arth., on *Spartina cynosuroides* Willd., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown May 22 on *Fraxinus lanceolata,* giving rise to pycnia May 29, and aecia June 4.[19]

8. PUCCINIA PHRAGMITIS (Schum.) Körn., on *Phragmites communis* Trin., collected at Scotia, Neb., by Rev. J. M. Bates, was sown May 14 on *Rumex crispus,* giving rise to pycnia May 22, and aecia May 29, both in the greatest abundance. Another collection by the same person, made at Grand Island, Neb., was sown May 17 on *R. crispus,* giving abundance of pycnia May 23, and aecia May 29.[20]

9. PUCCINIA OBLITERATA Arth., on *Agropyron* sp., collected

[17] For previous cultures see Bot. Gaz. 35: 19. 1903; Jour. Myc. 11: 54. 1905; 12: 16. 1906; 13: 197. 1907; 14: 15. 1908; and Mycol. 1: 234. 1909.

[18] For previous cultures see Bot. Gaz. 35: 20. 1903; Jour. Myc. 11: 57. 1905; 12: 16. 1906; and 14: 15. 1908.

[19] For previous cultures see Bot. Gaz. 29: 275. 1900; Jour. Myc. 11: 57. 1905; 12: 16. 1906; 14: 14. 1908; and Mycol. 1: 236. 1909.

[20] For previous cultures see Bot. Gaz. 29: 269. 1900; Jour. Myc. 9: 220. 1903; and 14: 15. 1908.

August 15, 1908, at Granby, Colo., by Mr. E. Bethel, was sown April 21 on *Thalictrum alpinum* and *T. dioicum*. There was no infection on the latter host, but on the former it was abundant, showing aecia May 6. Pycnia were so scantily produced that it required an extended search, aided with sections from the affected spots to discover any. A careful morphological study reveals no difference between the telial material used for this culture together with the aecia produced by it, and the telial material on the same host used last year, together with the aecia then produced on *Aquilegia*.[21] The gross appearance of the infected areas, the manner of the hypertrophy, and the remarkable paucity of pycnia, also combine to indicate that the two cultures belong to one species, although the production of aecia on both *Thalictrum* and *Aquilegia* by a single species is not in accordance with similar studies made in Europe.[22]

10. PUCCINIA MUHLENBERGIAE Arth. & Holw., on *Muhlenbergia glomerata* Trin., collected at Stockton, Kans., by Mr. E. Bartholomew, was sown May 17 on two plants of *Callirrhoe involucrata*, both giving rise to numerous pycnia May 31, and to aecia June 6 in one case and June 12 in the other. At the same time it was sown on *Napaea dioica*, *Althaea rosea* and *Sidalcea* sp., with no infection. These hosts are known to bear aecia of the same appearance and morphological structure as those secured by the culture on *Callirrhoe*, and the reason why they were not affected by the sowings is not clear, unless this species of rust is made up of races.[23]

11. PUCCINIA IMPATIENTIS (Schw.) Arth., on *Elymus striatus* Willd., collected at Lafayette, Ind., by Mr. A. G. Johnson, was sown May 6 on *Napaea dioica*, with no infection, and at the same time on *Impatiens aurea*, giving rise to pycnia May 15, and aecia in abundance May 25. Another collection on the same host, made by Mr. F. D. Kern at White House, St. Louis Co., Mo., was sown May 11 on *I. aurea*, producing pycnia May 21, and aecia May 29. It was also sown at the same time and produced no infection on *Napaea dioica*, *Callirrhoe involucrata*, *Thalictrum*

[21] See Mycol. 1: 250. 1909.

[22] See Klebahn, Wirtsw. Rostpilze 275, 276. 1904.

[23] For previous cultures see Mycol. 1: 251. 1909.

dioicum, Actaea alba, Caulophyllum thalictroides, Boehmeria cylindrica, Myosotis palustris, Mimulus ringens, Polemonium reptans, Hydrophyllum virginicum, Polygala Senega, Dirca palustris, Psoralea Onobrychis and *Ipomoea pandurata.*

Aeciospores from *Impatiens aurea* Muhl., were sown on three species of *Elymus.* For this purpose small plants bearing aecia were taken from the field, where they grew close together, and had presumably received infection from one source. These were established in pots, and the pots adjusted over the plants of *Elymus* to be infected, so the spores would drop of themselves upon the leaves of the grass, belljars being used as usual to secure the right degree of moisture for the germination of the spores. In this manner aeciospores were sown June 4 upon *Elymus virginicus* L., *E. canadensis* L. and *E. striatus* Willd. In all three cases uredinia began to show June 17, and continued to increase for some time, but the conditions were not such as to keep the plants in healthy condition for the maturing of telia.

Former cultures[24] had demonstrated the genetic connection between the aecia on *Impatiens* and telia on Elymus virginicus. The present season's work indicates that the rust on all species of *Elymus* in the region east of the Rocky Mountains belongs to one species, *Puccinia Impatientis.*

12. PUCCINIA POCULIFORMIS (Jacq.) Wettst., on *Agropyron pseudorepens* Scribn. & Sm., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown May 4 on *Berberis vulgaris,* giving rise to pycnia May 12, and numerous aecia May 24. Another collection on *Sitanion longifolium* J. G. Sm., made at Tolland, Colo., 9,000 feet altitude, by Mr. E. Bethel, was sown May 17 on *Berberis vulgaris,* and gave pycnia May 29, but owing to maturity of the leaves did not reach the production of aecia. Still another collection on *Sitanion longifolium,* made at Eldorado Springs, Colo., 4,500 feet altitude, by Mr. E. Bethel, was sown April 26 on *Berberis vulgaris,* and gave pycnia May 3, and aecia May 12, both in great abundance. On May 17 the barberry plant bearing aecia, produced in the last culture, was arranged over a pot in which young wheat plants (*Triticum vulgare* Vill.) were growing, in such a manner that the aeciospores could fall

[24] See Bot. Gaz. 35: 18. 1903; Jour. Myc. 10: 11. 1904; and 11: 57. 1905.

upon the wheat leaves. On May 29 urediniospores began to show, and their abundance increased for some time, but owing to the lateness of the season the wheat plants did not flourish, and in consequence teliospores were not formed.

This species of rust, which is the most injurious cereal rust known, is very common throughout the country, not only on cereals, but on many wild grasses. It has now been grown[25] in our series of cultures from telia on *Agropyron repens* from Vermont, *A. tenerum* from Iowa and Nebraska, *Agrostis alba* from Indiana and New York, *Cinna arundinacea* from Indiana, *Elymus canadensis* from Iowa and Wisconsin, and the two hosts mentioned above. In 1907 the aeciospores raised from telia on *Agrostis alba* obtained in Indiana were used to produce infection on wheat (*Triticum vulgare*) and barley (*Hordeum vulgare*), and in 1908 aeciospores raised from telia on *Agropyron tenerum* obtained in Nebraska were used for infection on oats (*Avena sativa*). This year the aeciospores raised from telia on *Sitanion longifolium* obtained in Colorado produced infection on wheat. More extended work is planned in regard to the problem of the transfer of this pernicious black or stem rust from wild grasses to the cultivated cereals, but enough has been accomplished to warrant the statement that although in the uredinial stage this rust shows racial strains that inhibit the ready transfer from one species of host to another, as has been shown by many European and American investigators, yet in the aecial stage racial strains play no part, and the barberry acts as a bridging host between each and every other gramineous host.

13. PUCCINIA SUBSTERILIS E. & E., on *Stipa viridula* Trin., collected April 16 at Eldorado Springs, Colo., by Mr. E. Bethel, bore abundance of amphispores, which were sown April 29 on plants of *Stipa viridula,* and gave rise to urediniospores in abundance, first observed May 24. A sowing at the same time on *Stipa spartea* gave no infection.

14. UROMYCES ANDROPOGONIS Tracy, on *Andropogon virginicus* L., collected at Morgantown, W. Va., by Dr. John L. Sheldon was sown June 4 on *Viola cucullata,* giving ten groups of pycnia,

[25] For previous cultures see Jour. Myc. 8: 53. 1902; 11: 57. 1905; 12: 17. 1906; 13: 198. 1907; and 14: 16. 1908.

first showing June 12. The leaves matured so rapidly that no aecia were formed. A sowing at the same date on *Viola primulifolia* gave no infection. This species of rust has been grown upon *Viola* by Dr. John L. Sheldon,[26] but previous attempts made in my own laboratory have failed.[27] The reason for the failures seems to be the tardiness in making the cultures, by which the violet leaves are too mature and ripen so rapidly that infection is not secured. I am indebted to Dr. Sheldon for the suggestions, field observations and culture material, which have enabled me to add this species to the list of completed life cycles.

15. UROMYCES SPARTINAE Farl., on *Spartina cynosuroides* Willd. collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown April 23 on *Lysimachia quadrifolia,* with no infection, and at the same date on *Steironema ciliatum* and *S. lanceolatum,* giving rise to pycnia May 5 on the former and May 8 on the latter. In both cases growth did not extend to the formation of aecia owing to the feeble condition of the host plants.[28] The confusion of this species of rust with *Uromyces acuminatus* Arth. has already been discussed above among unsuccessful cultures.

16. GYMNOSPORANGIUM GLOBOSUM Farl., on *Juniperus virginiana* L., collected at Asheville, N. C., by Mr. F. D. Kern, was sown May 15 on *Malus Ioensis, Crataegus punctata* and *C. coccinea,* with no infection on the first and second, but on the last giving rise to pycnia May 25 in abundance, followed by aecia which were mature July 26.[29]

17. GYMNOSPORANGIUM CLAVIPES C. & P., on *Juniperus sibirica* Burgsd., collected at Leland, Mich., by Mr. F. D. Kern, was sown June 5 on the fruit of *Amelanchier erecta,* giving rise to pycnia June 14, and to mature aecia August 3, both in abundance. At the same time it was sown on the leaves of *Crataegus punctata,* giving rise to numerous pycnia, but as the plant was not well established further development was soon checked.[30] There ap-

[26] Torreya 9: 55. 1909.

[27] See Mycol. 1: 232. 1909.

[28] For previous cultures see Jour. Myc. 12: 24. 1906; and 14: 17. 1908, under the name *U. acuminatus.*

[29] For previous cultures see Jour. Myc. 13: 200. 1907; 14: 18. 1908; and Mycol. 1: 239. 1909.

[30] For previous cultures see Jour. Myc 14: 18. 1908; and Mycol. 1: 239. 1909.

pears to be no noticeable difference between the pycnia and aecia grown this year from telia on the true juniper and those grown last year from telia on the true cedar, thus confirming the unique character of this species of rust in growing upon hosts of the two quite distinct sections of the genus *Juniperus.*

18. GYMNOSPORANGIUM NIDUS-AVIS Thax. on *Juniperus virginiana* L., collected at Asheville, N. C., by the writer, was sown March 22 on *Amelanchier canadensis,* without infection, and at the same time on *Crataegus Pringlei* and *Malus Ioensis,* both giving rise to an abundance of pycnia April 6. The infection on *Crataegus* did not perfect aecia, but that on *Malus* matured aecia in abundance by April 27.[31]

The telia of this collection were on the main branches of a tree thirty feet high, and when found were fully expanded. They formed wavy masses standing out two centimeters or more from the bark and extending in long lines of four or five decimeters, like orange colored ruffles or frills. The appearance was that of a large *Tremella,* and so unlike that of any *Gymnosporangium* before seen that not until it was examined under the microscope after returning to Lafayette was it accepted as a rust. It was found that the frills were the consequence of the large sori forming in rows and cracking the bark longitudinally.

19. GYMNOSPORANGIUM BETHELI Kern, on *Juniperus scopulorum* Sarg., collected in Colorado by Mr. E. Bethel, was sown May 14 on *Crataegus cerronis,* and gave rise to pycnia May 22 in abundance, and to first appearance of aecia June 14, the aecia being fully mature August 3.[32]

20. GYMNOSPORANGIUM CORNUTUM (Pers.) Arth., on *Juniperus sibirica* Burgsd., collected at Leland, Mich., by Mr. F. D. Kern, was sown June 5, on *Aronia nigra* and *Amelanchier erecta* with no infection, and at the same time on *Sorbus americana,* giving an abundance of pycnia June 15, but no aecia were formed owing to the weakness of the host plant. Another sowing was made from the same material June 7 on a cutting of *Sorbus aucuparia* placed in water, giving a few pycnia June 18, but the

[31] For previous cultures see Jour. Myc. 14: 19. 1908.

[32] For previous cultures see Jour. Myc. 14: 23. 1908; and Mycol. 1: 240. 1909.

leaves soon died. Still another sowing was made June 14 on *Sorbus americana,* producing numerous pycnia June 26, but the plant gradually died.[33]

21. GYMNOSPORANGIUM FLORIFORME Thax., on *Juniperus virginiana* L., collected at Aiken, S. C., by Mr. F. D. Kern and the writer, was sown March 26 on *Malus Malus* with no infection, and at the same time on *Crataegus coccinea,* giving pycnia in abundance April 12. The after development, however, was very slow, and by the middle of July aecia had only begun to show, and grew so very slowly that they did not reach full size, although observations were continued till November 11. Another sowing from the same material was made May 15 on the same host, resulting in a few pycnia, but no aecia. In both cases the infected leaves matured too rapidly for the very slow growing aecia, and besides, the host used is not a species on which natural infection is likely to occur.

Previous cultures have been made by Dr. R. Thaxter at Cambridge, Mass., and Prof. F. S. Earle at Auburn, Ala. Only a slight notice of these cultures has been published. A description and historical account of the species was recently published by Mr. F. D. Kern.[34] The telial form of the species is very similar in appearance to that of the common *Gym. Juniperi-virginianae.*

22. GYMNOSPORANGIUM EXTERUM Arth. & Kern, on *Juniperus virginiana* L., a living plant a little over six inches high, which has been growing in the greenhouse since being brought from Mammoth Cave, Ky., by Mr. F. D. Kern and the writer a year ago, was sown May 14 on *Porteranthus stipulatus* (*Gillenia stipulacea*), and gave rise to an abundance of pycnia May 22. On June 14 the first aecia appeared, which were mature June 26. The work duplicates and confirms that of last year.[35]

23. CALYPTOSPORA COLUMNARIS (A. & S.) Kühn, on *Vaccinium pennsylvanicum* Lam., collected at Pictou, Nova Scotia, by Prof. W. P. Fraser, was sown June 16 by suspending the moistened stems bearing the rust over potted plants of *Abies Fraseri.* On July 8 abundance of aecia appeared, without being preceded by

[33] For previous cultures see Mycol. 1: 240. 1909.

[34] Bull. Torrey Club 35: 503. 1908.

[35] For previous cultures see Mycol. 1: 253. 1909.

pycnia. European investigators have noted the absence of pycnia in this species, both in the field and in cultures. The suppression of the gametophytic sori, as in this case, is rare in heteroecious rusts.

This is the first culture yet made with American material. In 1880 Hartig made cultures at Munich, Germany, by using aeciospores from *Abies alba* and teliospores from *Vaccinium Vitis-idaea,* thus transferring in both directions.[36] The most extensive cultures were made by Dr. G. Winter in 1885 and 1886, in the garden of the Experiment Station at Halle, Germany.[37] He successfully sowed teliospores on *Abies nobilis, A. magnifica, A. concolor, A. balsamea* and *A. Fraseri,* natives of North America, and on eight other species of *Abies,* natives of various parts of the world.

After the sori made their appearance in our own cultures I wrote to Prof. Fraser, the collector of the culture material, describing the salient characters of the aecia, and inclosed infected leaves obtained by means of the culture. With this information he was able to go into the field and find the aecia on *Abies balsamea,* returning a collection which he made at Pictou, Nova Scotia, July 14, 1909,[38] the first known collection from North America. This stage of the fungus is probably common throughout the country, and the fact that it has been seen but once is doubtless due to its early appearance, lack of accompanying hypertrophy and discoloration, evanescent character, and general inconspicuousness.

SUCCESSFUL CULTURES REPORTED NOW FOR THE FIRST TIME: The following species have never before been cultivated, in America or elsewhere, so far as the writer knows. Although the number is small, it includes most valuable additions to our knowledge of American rusts. The study of the cedar rusts, which has been greatly advanced by the spring excursions of the last three years for personal observation and collection of material, is approaching a full survey of the species of the eastern United States, although an unknown number of species remain in the western mountains yet to be investigated.

[36] See Klebahn, Die wirtsw. Rostpilze 391. 1904.

[37] Hedwigia 26: 28. 1887.

[38] See Fraser, Science 30: 814. 1909.

1. PUCCINIA on *Andropogon Hallii* Hack., collected at Red Cloud, Neb., by Rev. J. M. Bates, was sown June 3 on thirteen species of hosts with no infection, as follows: *Carduus undulatus, Ambrosia trifida, Lithospermum canescens, Myosotis palustris, Hydrophyllum virginicum, Lepargyraea canadensis, Symphoricarpos parviflorum, Napaea dioica, Boehmeria cylindrica, Thalictrum dioicum, Delphinium scaposum, Cassia Chamaecrista* and *Petalostemon purpureus.* The same material was sown the day following on four other species with no infection, viz., *Amorpha nana, Baptisia tinctoria, Psoralea Onobrychis* and *Xanthoxylon americanum.* Each of these hosts is known to harbor aecia whose telial connection has not yet been experimentally ascertained. The material being in unusually good condition an attempt was made to sow it on all unconnected aecial hosts available at the time, hoping in this way to strike the right one, no field clues having been secured. This is a precarious method, but in this instance it succeeded, as among the hosts was included *Ceanothus americanus,* on which a sowing was made June 3, giving rise to numerous pycnia June 12, and an abundance of aecia June 22.

The telial form of this species was first detected by the writer while preparing the material for the third fascicle of Arthur and Holway's Uredineae Exsiccatae, and was referred to *Puccinia Cesatii* Schröt., on account of the similarity of the urediniospores to those of that species.[39] Sydow in his Monograph rightly called this reference in question, and suggested that it might be a new species, but did not give a name or description.[40]

The aecial form of this species was described by Ellis and Kellerman in 1884, under the name *Aecidium Ceanothi,* from a collection made at Manhattan, Kans. The form is not only known from Kansas, but also from Nebraska, and northwestern Wisconsin.

Puccinia Ceanothi (Ellis & Kellerm.) nom. nov. (*Aecidium Ceanothi* Ellis & Kellerm., Bull. Torry Club 11: 114. 1884.)

O and I. On *Ceanothus ovatus* Desf., Manhattan, Kans., May 20, 1884, *W. A. Kellerman* (type); Rooks Co., Kans., May, 1898,

[39] Bull. Lab. Nat. Hist. Iowa Univ. 5: 181. 1901.

[40] Sydow, Monog. Ured. 1: 723. 1903.

E. Bartholomew; Nebraska, 1899, *A. J. Bell;* Gordon, Wis., July 12, 1907, *J. J. Davis.*

II. Uredinia hypophyllous, oblong-linear, pulvinate, early naked, chestnut-brown, only slightly pulverulent; urediniospores globose or nearly so, 23–33μ in diameter, wall cinnamon-brown, uniformly thick, 3–6μ, finely and closely verrucose, pores five or more, scattered.

III. Telia hypophyllous, oblong or linear, early naked, pulvinate, firm, chocolate-brown; teliospores broadly ellipsoid or obovate, 22–30 by 30–40μ, somewhat constricted at the septum, rounded at both ends, or narrowed below, wall smooth, medium thick, 3μ, much thickened at apex, 6–10μ, chestnut-brown; pedicel colored, once to twice length of spore.

On *Andropogon Hallii* Hack., Manhattan, Kans., no date, *M. A. Carleton;* Howard Co., Neb., September, 1889, *H. J. Webber;* Kennedy, Neb., Sept. 7, 1908, *J. M. Bates* (Barth., Fungi Columb. *2756*); Red Cloud, Neb., May 7, 1909, *J. M. Bates.*

2. GYMNOSPORANGIUM EXIGUUM Kern, on *Juniperus virginiana* L., collected at Austin, Texas, by Dr. F. D. Heald and Mr. F. A. Wolf, was sown April 26 on *Amelanchier canadensis* with no infection, and at the same time on *Crataegus Pringlei,* giving abundant pycnia May 6, and aecia June 26.

This southernmost species of cedar rust was described a year ago[41] from telial material that was collected in the vicinity of that used for the cultures. The telial description may now be supplemented by a description of the pycnia and aecia. Only one collection of aecia from the field is yet known that can be assigned to this species. It was obtained at Boerne, Texas, not far from San Antonio, and is to some extent on the leaves, but mostly on the fruit of some undetermined species of *Crataegus.* While trees of red cedar of more than one species are abundant in southern Texas where the rust is found, trees of *Crataegus* are rare, and the rust is probably not common.

O. Pycnia fruiticolous and epiphyllous, gregarious, in irregular groups 1–4 mm. across, on discolored hypertrophied areas, prominent, conspicuous, honey-yellow soon becoming blackish, globoid or depressed globoid, 150–165μ in diameter by 100–130μ high; ostiolar filaments 50–65μ long.

I. Aecia fruiticolous and hypophyllous, sparsely arranged in irregular groups, causing considerable hypertrophy of the veins,

[41] Bull. Torrey Club 35: 508. 1908.

petioles, or fruits, cylindrical, 2–3 mm. high; peridium rupturing at the apex, margin not splitting much, erect, peridial cells, usually seen in face view, broadly lanceolate, 29–40 by 70–90μ, inner and side walls thick, 9–14μ, closely spinulose with spine-like papillae up to 6μ long, outer wall thinner, about 3μ, sculptured like the inner and side walls but with shorter papillae; aeciospores globoid or broadly ellipsoid, 22–25 by 26–31μ, wall cinnamon-brown, medium thick, 2–3μ, finely verrucose; pores distinct, 6–8, scattered.

On *Crataegus* sp., Boerne, Texas, June 12, 1908, *G. G. Hedgcock.*

3. GYMNOSPORANGIUM sp. nov. The chain of circumstances which led up to the detection and final culture of this very interesting species of rust is given with sufficient detail in the introduction to this paper, and need not be repeated. Material collected by Mr. F. D. Kern, June 4, 1909, at Leland Mich., on *Juniperus horizontalis* Moench, was sown, June 5, on one plant of *Amelanchier erecta,* and two plants of *A. canadensis.* Numerous pycnia appeared on all three plants, one June 14, and the other two June 16. Owing to the fact that the season was well advanced, and the foliage on the *Amelanchier* plants quite mature, by the time well developed telia could be obtained in the northern habitat, the leaves on all three plants used for cultures ripened and fell before aecia appeared. The field collection of the previous autumn, however, supplied authentic material for study, and the results are not open in the slightest degree to doubt.

It is very gratifying to establish the relationship of the horn-like aecia on *Amelanchier,* as it is now possible to distribute the three very similar forms, that have heretofore gone under one name, and supposed to belong to one cosmopolitan species. The three species are: *Gym. cornutum,* with aecia on *Sorbus,* common to Europe and America, *Gym. Davisii,* with aecia on *Aronia,* known only in America, and the present form with aecia on *Amelanchier,* also known only from America. The first two have their telia on the true juniper, while the last has telia on the red cedar. The new form has been studied morphologically by Mr. F. D. Kern, who has drawn up the following description and supplied the name.

Gymnosporangium corniculans Kern sp. nov.

O. Pycnia epiphyllous, gregarious, in small groups 0. 5–1 mm. across, on discolored spots, rather prominent and conspicuous, honey-yellow, becoming blackish, slightly flattened globose, 130–175μ in diameter by 130–160μ high; ostiolar filaments 50–80μ long.

I. Aecia hypophyllous, crowded in irregular or annular groups, 2–5 mm. across, cylindrical or horn-shaped, acutish at apex, 2–3.5 mm. high; peridium tardily dehiscent by longitudinal slits along the sides, peridial cells usually seen in face view, broadly lanceolate, 16–23 by 64–96μ, inner and side walls rather thick, 5–7μ, moderately verrucose with oval or roundish papillae and a few elongated papillae interspersed, outer wall thin, 1.5–2μ, smooth; aeciospores globoid, 19–26 by 23–32μ, wall dark cinnamon-brown, rather thick, 3–4μ, finely verrucose, appearing nearly smooth.

On *Amelanchier canadensis* (L.) Medic., Burlington, Vt., Sept. 25, 1897, *W. A. Orton;* Fort Spring, W. Va., Sept. 14, 1906, *J. L. Sheldon;* Granville, Mass., Sept. 22, 1890, *A. B. Seymour* (Seym. & Earle, Econ. Fungi *248*[a]); *Amelanchier erecta* Blanch., Isle Royale, Mich., Aug. 28, 1901, *Stuntz* & *Allen;* Leland, Mich., Sept. 7, 1908, *Arthur* & *Kern; Amelanchier intermedia* Spach, Taughannock Falls, N. Y., Sept. 3, 1908, *Whetzel, Wallace* & *Reddick.*

III. Telia caulicolous, from a perennial mycelium, appearing on irregularly lobed, gall-like excrescences 2–15 mm. or more in diameter, unevenly distributed, often separated by the scars of the sori of previous seasons, conical or cylindrical-acuminate, 1.5–2 mm. in diameter at the base by 3–5 mm. high, dark chestnut-brown; teliospores 2-celled, ellipsoid, 18–21 by 35–50μ, slightly or not constricted at the septum, slight hyaline thickenings over the germ-pores, wall cinnamon-brown, thin 1–1.5μ; pedicel uniform, long; pores 1–2 in each cell, near the septum.

On *Juniperus horizontalis* Moench, Leland, Mich., June 4, 1909, *F. D. Kern.*

4. GYMNOSPORANGIUM sp. nov.—Among the material collected at Santee Canal, S. C. by Mr. F. D. Kern on March 18, 1909, was an abundance of telia on *Juniperus virginiana,* in part extending along the smaller branches often for a foot or more, and referred to above under unsuccessful cultures, and in part forming rather distinct globoid galls from very small up to a half inch or even more in diameter. It was difficult to tell in the field whether there were two species associated or only the incidental

variation of a single species, as both forms bore prominent dark brown telia of quite similar appearance. The cultures, however, settled the question. Sowings were made of the gall-form March 22, on *Crataegus punctata* giving rise to yellow spots after fifteen days, on which pycnia appeared by April 12, but the leaves matured before aecia could form. Other sowings were made May 14 on *Crataegus coccinea* and *C. cerronis,* giving rise to a few belated pycnia on the former, first observed June 14, but on the latter to an abundance of pycnia May 25 and mature aecia October 27.

This fortunate culture adds another species, with life cycle known, to the Atlantic coast rusts of the common red cedar. It does not appear to be represented in herbaria, either in the aecial or telial form, except by some small unnamed fragments. Possibly collections of aecia have been referred to *G. globosum,* which grows on *Crataegus,* although the peridia differ in gross appearance. An interesting point is that this species produces cornute aecia, the first to be noticed on *Crataegus.* The following name and description have been supplied by Mr. Kern, who has also increased the number of aecial hosts by searching in phanerogamic collections.

Gymnosporangium trachysorum Kern, sp. nov.

O. Pycnia epiphyllous, gregarious, in groups 1–2 mm. across, prominent, punctiform, orange-yellow becoming brownish-black, globoid, 144–165μ in diameter by 112–128μ high; ostiolar filaments 75–90μ long.

I. Aecia hypophyllous, rather few in irregular groups 2–5 mm. across, on discolored slightly thickened spots 5–10 mm. or more across, cylindrical, 2–4 mm. high, 0.2–0.3 mm. in diameter; peridium remaining horn-like, finally rupturing by longitudinal slits along the sides, peridial cells long and narrow in side view, 15–19 by 32–90μ, outer wall thin 1.5–2μ, nearly or quite smooth, inner and side walls moderately thick, 3–6μ, closely spinulose with short spine-like papillae interspersed with lower oval or ridge-like papillae; aeciospores globoid or ellipsoid, 15–23 by 18–27μ, wall chestnut-brown, rather thick, about 2.5–3μ, very minutely verrucose, appearing almost smooth; pores about 6, scattered.

On *Crataegus Marshallii* Egg. (*C. apiifolia* Michx.) Auburn, Lee Co., Alabama, Nov. 20, 1897, *F. S. Earle;* Aldenbridge, La.,

Nov. 1, 1898, *Wm. Trelease; Crataegus flavo-carius* Ashe, Salisbury, N. C., Sept. 11 and 12, 1908, *W. W. Eggleston; Crataegus Phaenopyrum* (L. f.) Medic. (*C. cordata* Ait.), Salisbury, N. C., Oct. 7, 1908, Catawba, N. C., Sept. 13 and 14, 1908, *W. W. Eggleston.*

III. Telia cauliculous, from a perennial mycelium, appearing on abruptly fusiform or globoid gall-like enlargements, 0.5–1.5 cm. in diam. by 0.5–3 cm. long, unevenly disposed, sometimes densely crowded, often separated by the scars of the sori of previous seasons, more or less wedge-shaped, 1.5–2 mm. broad by 2–4 mm. long at base by 6–10 mm. high, surface very rough with irregular warts and ridges, dark chestnut-brown; teliospores 2-celled, ellipsoid, 18–21 by 37–45μ, wall cinnamon-brown, medium thin 1.5–2.5μ; pedicel hyaline, very long, uniform; pores 1 or 2 in each cell, near the septum.

On *Juniperus virginiana* L., Santee Canal, S. C., March 18, 1909, *Frank D. Kern* (type); Agricultural College, Miss., April 10, 1893, *S. M. Tracy.*

SUMMARY.

The following is a complete list of the successful cultures made during the year 1909. It is divided into two series, species that have previously been grown in cultures and reported by the writer or other investigators, and species whose culture is now reported for the first time.

A. Species Previously Reported.

1. *Puccinia Peckii* (DeT.) Kellerm.—Teliospores on *Carex lanuginosa* Michx. and on *C. trichocarpa* Muhl., sown on *Onagra biennis* (L.) Scop.

2. *Puccinia Caricis* (Schum.) Schröt.—Teliospores on *Carex aristata* R. Br., sown on *Urtica gracilis* Ait.

3. *Puccinia universalis* Arth.—Teliospores on *Carex stenophylla* Wahl., sown on *Artemisia dracunculoides* Pursh.

4. *Puccinia Caricis-Asteris* Arth.—Teliospores on *Carex festiva* Dewey, sown on *Aster adscendens* Rydb.

5. *Puccinia subnitens* Diet.—Teliospores on *Distichlis spicata* (L.) Greene, sown on *Atriplex hastata* L. and *Chenopodium album* L.

6. *Puccinia amphigena* Diet.—Teliospores on *Calamovilfa longifolia* (Hook.) Hack., sown on *Smilax hispida* Muhl.

7. *Puccinia fraxinata* (Schw.) Arth.—Teliospores on *Spartina cynosuroides* Willd., sown on *Fraxinus lanceolata* Borck.

8. *Puccinia Phragmitis* (Schum.) Körn.—Teliospores on *Phragmites communis* Trin., sown on *Rumex crispus* L.

9. *Puccinia obliterata* Arth.—Teliospores on *Agropyron* sp., sown on *Thalictrum alpinum* L.

10. *Puccinia Muhlenbergiae* Arth. & Holw.—Teliospores on *Muhlenbergia glomerata* Trin., sown on *Callirrhoe involucrata* (T. & G.) A. Gray.

11. *Puccinia Impatientis* (Schw.) Arth.—Teliospores on *Elymus striatus* Willd., sown on *Impatiens aurea* Muhl., and aeciospores on *Impatiens aurea* Muhl., sown on *Elymus virginicus* L., *E. canadensis* L., and *E. striatus* Willd.

12. *Puccinia poculiformis* (Jacq.) Wettst.—Teliospores on *Agropyron pseudorepens* Scribn. & Sm., and *Sitanion longifolium* J. G. Sm., sown on *Berberis vulgaris* L., and aeciospores on *Berberis vulgaris* L., sown on *Triticum vulgare* Vill.

13. *Puccinia substerilis* E. & E.—Amphispores on *Stipa viridula* Trin., sown on same host.

14. *Uromyces Andropogonis* Tracy.—Teliospores on *Andropogon virginicus* L., sown on *Viola cucullata* Ait.

15. *Uromyces Spartinae* Farl.—Teliospores on *Spartina cynosuroides* Willd., sown on *Steironema lanceolatum* (Walt.) A. Gray and *S. ciliatum* (L.) Raf.

16. *Gymnosporangium globosum* Farl.—Teliospores on *Juniperus virginiana* L., sown on *Crataegus coccinea* L.

17. *Gymnosporangium clavipes* C. & P.—Teliospores on *Juniperus sibirica* Burgsd., sown on *Amelanchier erecta* Blanch., and *Crataegus punctata* Jacq.

18. *Gymnosporangium nidus-avis* Thax.—Teliospores on *Juniperus virginiana* L., sown on *Crataegus Pringlei* Sarg., and *Malus Ioensis* (Wood) Britt.

19. *Gymnosporangium Betheli* Kern.—Teliospores on *Juniperus scopulorum* Sarg., sown on *Crataegus cerronis* A. Nels.

20. *Gymnosporangium cornutum* (Pers.) Arth.—Teliospores on *Juniperus sibirica* Burgsd., sown on *Sorbus americana* Marsh., and *S. Aucuparia* L.

21. *Gymnosporangium floriforme* Thax.—Teliospores on *Juniperus virginiana* L., sown on *Crataegus coccinea* L.

22. *Gymnosporangium exterum* Arth. & Kern.—Teliospores on *Juniperus virginiana* L., sown on *Porteranthus stipulatus* (Muhl.) Britt.

23. *Calyptospora columnaris* (A. & S.) Kühn.—Teliospores on *Vaccinium pennsylvanicum* Lam., sown on *Abies Fraseri* Pursh.

B. Species Reported Now for the First Time.

1. *Puccinia Ceanothi* (Ellis & Kellerm.) Arth.—Teliospores on *Andropogon Hallii* Hack., sown on *Ceanothus americanus* L.

2. *Gymnosporangium exiguum* Kern.—Teliospores on *Juniperus virginiana* L., sown on *Crataegus Pringlei* Sarg.

3. *Gymnosporangium corniculans* Kern.—Teliospores on *Juniperus horizontalis* Moench, sown on *Amelanchier erecta* Blanch., and *A. canadensis* (L.) Medic.

4. *Gymnosporangium trachysorum* Kern.—Teliospores on *Juniperus virginiana* L., sown on *Crataegus punctata* Jacq., *C. coccinea* L., and *C. cerronis* A. Nels.

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